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Canadian Science Advisory Secretariat
Science Advisory Report 2008/047

POPULATION ASSESSMENT: STELLER SEA LION (*EUMETOPIAS JUBATUS*)

Photo: Michael A. Bigg

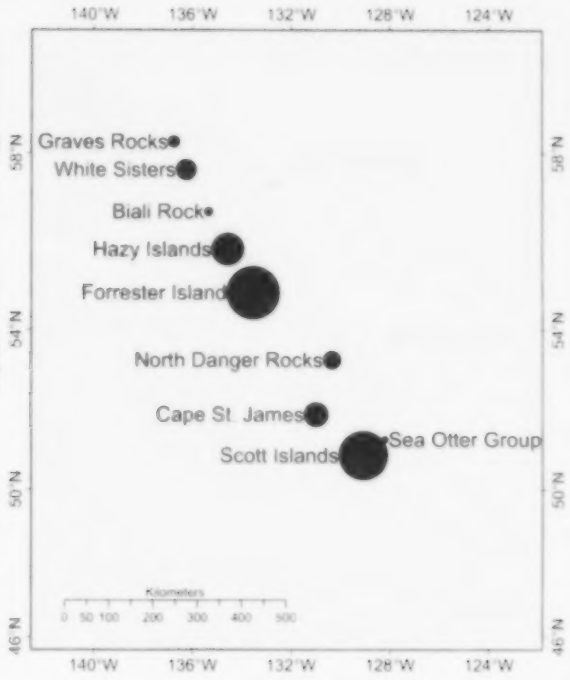

***Figure 1**. Map showing the location of Steller sea lion breeding areas in B.C. and neighboring waters in SE Alaska. The species does not breed in Washington, with the closest rookeries to the south being in southern Oregon. The size of symbols is drawn proportional to pup production at each rookery during the most recent survey in 2005-2006.*

Context

Steller sea lions inhabit the cool-temperate coastal waters of the North Pacific Ocean from California, north to the Bering Strait, and south along the Asian coast to Japan. They are the largest member of the family Otariidae and only one that resides year-round and breeds in Canadian waters. Three distinct populations are recognized: an eastern stock (California to SE Alaska), a western stock (Gulf of Alaska, Bering Sea, and the Aleutian and Commander Aleutian Islands) and an Asian stock (Russia).

In B.C., Steller sea lions breed at traditional rookeries on the Scott Islands off the north tip of Vancouver Island, at Cape St. James off the southern tip of the Queen Charlotte Islands, on the Sea Otter Group off the central coast, and on North Danger Rocks off the northern mainland coast. There is also a major rookery situated just north of the BC border on Forrester Island in Alaska.

During 1912-68, Steller sea lions in B.C. were subject to predator control programs and commercial harvests. A total of 55,000 sea lions were killed during 1912-68, and by the 1970s breeding populations had been reduced to roughly 25-33% of the peak historic levels thought to have been present in the early 1900s.

December 2008 (Updated: April 2009)

Canada

SUMMARY

- DFO has conducted 10 province-wide aerial surveys since the early 1970s to monitor Steller sea lion populations. Beginning in 1994, the surveys have been conducted at 4-year intervals as part of an international range-wide survey that extends from California to Alaska to Russia. Surveys are timed to coincide with the end of the breeding season so as to provide an estimate of pup production, as well as counts of juveniles and adults (non-pups).
- The abundance of Steller sea lions in B.C. has increased at an overall rate of 3.5% per year since the early 1970s. Non-pup numbers were stable until the early 1980s, but subsequently increased at 5.0% per annum. Pup numbers were stable until the mid-1980s, but subsequently increased at 7.9% per annum.
- During the most recent survey in 2006, a total of 19,818 sea lions were counted in B.C. This included 4,118 pups and 15,700 non-pups (7,171 on rookeries and 8529 on non-breeding haulout sites).
- The counts from aerial surveys represent minimum abundance because, except for pups, some animals would be foraging at sea and missed. Based on estimated pup production and a range of multipliers derived from life table statistics, it was calculated that at least 20,000 and as many as 28,000 Steller sea lions currently inhabit coastal waters of B.C.
- Abundance of Steller sea lions has also increased in recent years at neighboring rookeries in SE Alaska and Oregon (the species does not breed in Washington). This contrasts sharply with the western stock of Steller sea lions (Gulf of Alaska, Bering Sea, Aleutian Islands, and Russia), which has declined by 80% since the 1970s and been designated as *endangered*.
- Recovery of Steller sea lion populations in the eastern portion of range has renewed concern over their impact on fishery resources and their role in the ecosystem.

BACKGROUND

Species Biology

The Steller sea lion (*Eumetopias jubatus* Schreber 1776) is the largest otariid and only member of the family that resides year-round and breeds in Canadian waters. Steller sea lions exhibit significant sexual dimorphism. Adult females average 2.1-2.4 meters in length and weigh 200-300 kg. Adult males are noticeably larger, attaining a length of 2.7-3.1 meters and weighing 400-800 kg. Pups are born in June and weigh 16-23 kg at birth.

Steller sea lions have a polygamous mating system and congregate on traditional rookeries to breed. Animals tend to return to rookeries on which they were born. The rookeries currently in use in B.C. were all known to have existed when the first sea lion surveys were conducted in 1913. Males mature at 3-7 years of age, but only the dominant bulls, most aged 9-13 years, breed. They are the first to arrive on rookeries in May to stake out territories, which they will defend while fasting for the next 20-68 days. Females mature at 3-6 years of age. Pregnant cows arrive on rookeries throughout June, and give birth to a single pup within a few days. Pups cannot swim at birth and are confined to rookery for the first month of life. Mothers remain with newborn pups for the first week and then make regular feeding trips lasting 1 day on average, alternated with a day on shore.

During summer, non-breeding animals are found at year-round haulout sites. There are 23 such sites distributed off B.C., primarily along the outer exposed coast. In August, animals disperse from rookeries to feed, and begin to occupy numerous winter haulout sites, many of which are located in inside protected waters. Young animals maintain bonds with their mothers and continue to nurse into their 2nd or even 3rd year.

The species is non-migratory, but there are well-defined local seasonal movements in some areas. In southern part of range, both Steller and California sea lion migrate north along the Oregon and Washington coast. This coincides with a dramatic increase in the number of sea lions wintering off southern Vancouver Island. Non-breeding animals have been know to disperse distances of up to 1,700 km from where they were born.

Mortality of pups during the first month of life appears to be high and influenced by factors such as storms. The primary cause of death of pups is drowning, mainly because they are not able to get back out of the water. Deaths can also result from pups being bitten, tossed or trampled by older animals, or becoming separated from their mothers. Rookeries are therefore particularly sensitive to disturbances during the breeding season.

Juvenile mortality is difficult to measure due to potential sampling biases, but appears to be fairly high for both sexes – it has been estimated that 48% of females and 26% of males survive to 3 years of age. Mortality rates are significantly lower for adults: 10-15% per year for females, and 13-25% for males, resulting in a progressively skewed sex ratio favoring females. The oldest animals in the wild were aged about 18 years for males and 30 years for females, although very few individuals attain such old ages.

Steller sea lions are opportunistic predators in that they tend to feed on prey that are locally and seasonally most abundant or accessible. Preferred prey appear to be small or medium-sized schooling fishes, which in B.C. include species such as herring, hake, sandlance, salmon, dogfish, eulachon and sardines. Bottom fish, such as rockfish, flounder and skate, can also be important dietary items. In addition to fish, squid and octopus are sometimes consumed. Steller sea lions have also been observed to occasionally prey on birds and other mammals including neonate fur seals and harbour seals.

Bioenergetic models predict that daily food requirements for Steller sea lions in the wild are about 15-20 kg for mature females and 30-35 kg for mature males. However, these figures vary with prey quality - animals feeding on low fat fishes such as pollock require significantly more prey than those feeding on fattier fishes such as herring.

Need for Advice

Prior to 1970, predator control programs and commercial harvests had reduced breeding populations of Steller sea lions in B.C. to roughly 25-33% of the peak historic levels present in the early 1900s. An earlier assessment published in 1985 found no evidence that populations were recovering.

The western stock of Steller sea lions (Gulf of Alaska, Bering Sea, Aleutian Islands, and Russia) has declined precipitously since the 1970s, and has been designated as *endangered* under the U.S. *Endangered Species Act*. Although such declines were not evident in the eastern stock (California to SE Alaska), the U.S. nevertheless designated the eastern stock as *threatened* due

to uncertainty at the time regarding stock delineation and concerns the declines may spread eastward.

In 2003, COSEWIC recommended that the Steller sea lion be designated as *Special Concern* in Canada. The recommendation was based primarily on the basis of the unexplained declines that had occurred in western Alaska, the species is sensitive to disturbances while on land, and the limited number of breeding sites in Canadian waters. As required under SARA, DFO is developing a Management Plan for Steller sea lions.

It is now recognized the eastern stock of Steller sea lions has increased significantly in recent years. Managers can anticipate renewed interest over impact of sea lions on other fishery resources, and their role in ecosystem. Addressing such questions requires information on population status and abundance.

ASSESSMENT

Research Results

Historical kill and sighting records were compiled and examined to assess the effect of kills had on populations. During 1923-39, an estimated 20,000 animals (including 7,000 pups) were killed at the Sea Otter Group. Pup production at this rookery declined from about 1,200 to fewer than 10 pups, and until the last few years it had been used as a haulout mainly by non-breeding animals.

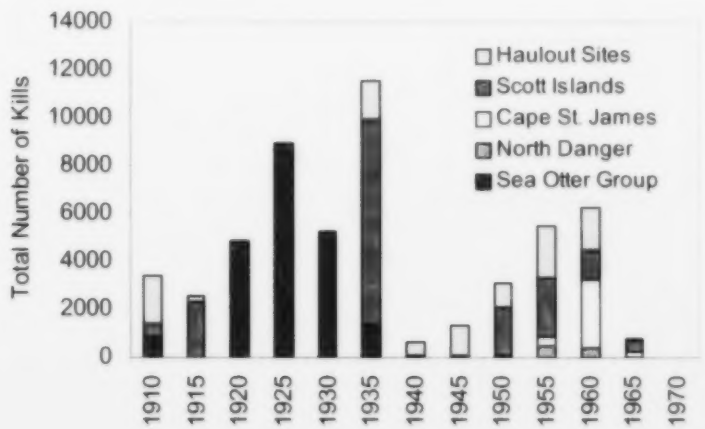

Figure 2. *Numbers of Steller sea lions (pups, juveniles and adults) killed during control programs and harvests in B.C. during 1912-68.*

Control programs, although not as intense, were also undertaken in other areas. During 1936-39, 7,500 animals were killed on the Scott Islands. Control programs were suspended during WW II, but the Canadian navy and air force may have killed large numbers of animals during bombing practices. During 1956-66, another 11,600 animals were killed at rookeries and haulouts throughout B.C., including some which were harvested for pelts and mink food, but neither operation proved economically viable.

When the first Steller sea lion counts were made in 1913, which was prior to any large-scale kills, the breeding population on rookeries was estimated to be on the order of 14,000 animals. With the elimination of rookeries on the Sea Otter Group, numbers had fallen to roughly 12,000 by 1938. By 1956, kills at other rookeries had reduced numbers to 8,900-9,400. The population declined sharply with the resumption of control programs and harvests in 1956-66, and by the time the species was protected in 1970, total numbers on rookeries had been reduced to about 3,400 animals.

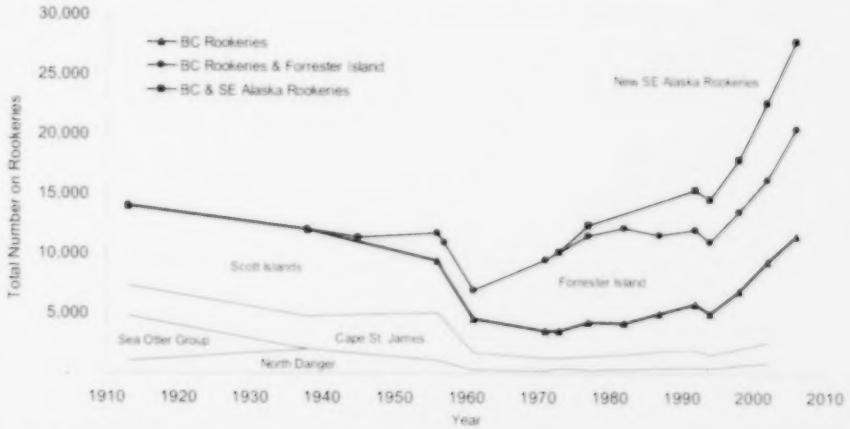

Figure 3. *Historic trends in total numbers of Steller sea lions (pups, juveniles and adults) on breeding rookeries in B.C. (lower thick line), Forrester Island, Alaska (middle thick line), and other new rookeries in SE Alaska (upper thick line). The thin black lines show the distribution of animals among rookeries within B.C.*

Since the early 1970s, DFO has conducted a series of 10 aerial surveys to monitor the status of Steller sea lion populations. Beginning in 1994, the surveys have been conducted at 4-year intervals as part of an international range-wide survey involving government agencies in California, Oregon, Washington, Alaska and Russia. Surveys are timed to coincide with the end of the breeding season so as to provide an estimate of pup production, as well as counts of juveniles and adults (non-pups).

Recent surveys indicate that both non-pup and pup numbers have increased in B.C. since the early 1970s. Non-pup numbers were stable until the early 1980s, but subsequently increased at 5.0% per annum. Pup numbers were stable until the mid-1980s, but subsequently increased at 7.9% per annum.

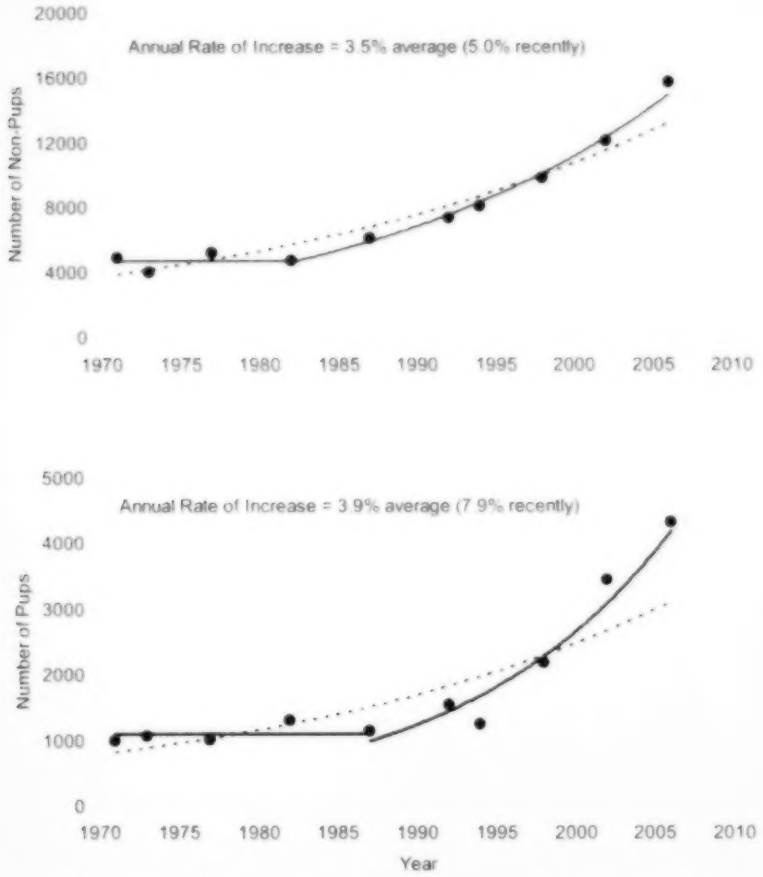

Figure 4. *Number of non-pups (top) and pups (bottom) counted during aerial surveys in B.C. during 1971-2006. Dashed lines show population trends over the entire study period, and solid lines show changes in population trends during the study period.*

Abundance of Steller sea lions has also increased in SE Alaska. While control programs were underway in B.C., a new rookery became established at Forrester Island, situated about 50 km north of the Alaska border. It has since grown into the world's largest Steller sea lion rookery.

Several other new rookeries also became established in SE Alaska during the 1980s and 90s. Combined abundance in B.C. and SE Alaska – which are difficult to separate due to the large rookery just north of the border, appears to have increased steadily since the 1960s at a rate of 3.0% per year, and at rate of 4.5% since the early 1980s. During the 1960s and 70s, most of the growth occurred Forrester Island, but during the 1980s and 90s most of it has occurred to the south on existing rookeries B.C., or to the north on new rookeries established in SE Alaska. The reason for this shift in distribution is unknown. Abundance of Steller sea lions in Washington and Oregon also appears to be increasing.

Counts from aerial surveys represent minimum abundance since non-pups make foraging trips to sea, and these dispersed animals are missed in counts made at haulout sites and rookeries. However, because pups are confined to rookeries for the first month of life, total actual

abundance can be indirectly determined based on estimates of pup production and life tables (i.e. ratios of pups to older animals).

Pups are more difficult to census than older animals because they are dark and tend to blend in with the substrate. They are also small and easily obscured by other animals, or hidden in crevices or behind rocks and outcroppings. Traditionally, other agencies have made pups counts from the ground by driving older animals off the rookery and walking through it to tally pups, but these ground counts are highly disruptive. DFO has therefore counted pups from oblique 35mm slides or digital images taken during aerial surveys. In recent years, researchers in the U.S. have developed specialized vertical medium-format photographic techniques that provide pup counts that appear to be as accurate as those made from the ground.

Working collaboratively with other agencies, DFO evaluated counts made from oblique 35mm photos by comparing them with those made concurrently from the ground (on Forrester Island in Alaska) or from aerial vertical medium-format images (on B.C. rookeries). The comparison indicated that some pups were missed in oblique 35mm slides. For B.C. rookeries, about 4% of pups were missed, and a correction factor of 1.05 (95% Confidence Interval of 1.02-1.08) was therefore applied to pup counts from oblique 35mm slides. At Forrester Island, about 22% of pups were missed, and a correction factor of 1.28 (95% CI of 1.12-1.44) was applied. The correction was likely greater for the latter site because it was larger and had to be circled more widely, such that pups were photographed at more oblique angles.

In 2006, a total of 4,800 pups were estimated to have been born in B.C. Based on a range of multipliers derived from life table statistics, it was calculated that a Steller sea lion population of at least 20,000 and as many as 28,000 would be required to support this level of pup production.

Sources of Uncertainty

Estimates of total abundance of Steller sea lions are based on estimates of pup production and life table statistics, both of which are subject to error.

Almost all pups are born on traditional rookeries during June, and they are confined to land for the first month of life. Surveys of rookeries in very late June or early July can therefore, in theory, provide an essentially complete count of annual pup production. As has been the practice in other Steller sea lion assessments, an arbitrary correction factor of 1.1 was applied to pup counts to account for pups that may have been born and died or swept off rookeries prior to surveys, or pups born following the survey. While this correction seems reasonable, there is little information on the actual number of pups missed, and the number could vary from year to year and between sites. It is also possible, but highly unlikely, that new rookeries have become established in B.C. that have not yet been discovered. In SE Alaska, the only region where new rookeries have become established, they formed at traditional haulout sites, which are included in the province-wide aerial surveys.

In practice, pups are more difficult to census than older age-classes. Ground drive-counts have not been conducted in B.C. since most rookeries have been designated as Ecological Reserves or National Parks, and such disturbances would not be permitted. However, there was a high degree of correlation between pups counts made from oblique 35mm slides and those made from vertical medium-format images, which in other regions have been shown to be as accurate as ground counts. For rookeries in B.C., only about 4% of pups were missed the oblique slides,

and this bias appeared to be fairly constant between years and among sites. At Forrester Island, however, comparison of oblique 35mm slides with both ground drive-counts and vertical medium-format images indicated that about 20% of pups were missed in the 35mm slides. It is not known why a greater proportion of pups were missed at Forrester Island. One possible explanation is that the pupping sites tend to be larger at Forrester Island, which have to be circled more widely, such that pups are photographed at more oblique angles. The factors affecting the consistency of corrections for pup counts from oblique 35mm slides warrant further examination.

In addition to the uncertainty in estimating pup production, there is considerable uncertainty associated with the pup to non-pup ratio multipliers used to extrapolate total abundance. Published life tables for Steller sea lions have all been derived from one sample of animals collected in the Gulf of Alaska in the late 1970s. There may be sampling biases in such collections due to segregation of animals by sex, age and reproductive status. Moreover, vital rates will vary depending on the status of populations. The Gulf of Alaska sample was collected during a period of stability just prior to sharp declines that occurred in the 1980s, whereas populations in B.C. and neighbouring waters have been increasing since the early 1960s. Matrix population projection models were used to assess how pup multipliers would change for an increasing population. The simulations indicate the multiplier could theoretically range from as low as 4.0 if the population growth were attributable to increased fecundity or earlier maturation, to as high as 5.8 if the growth were due to increased juvenile survival, and intermediate if due to improvement in adult survival. Due to the lack of information on the demographic differences between stable and increasing populations, there is considerable uncertainty associated with extrapolating total abundance from estimates of pup production.

Survey procedures are quite straightforward for non-pups. Non-pups tend to occur on traditional rookeries and haulout sites, are highly visible and easily counted from 35mm oblique photographs, and are not disturbed by survey aircraft. Counts are generally made between 10:00 and 18:00 when peak numbers are expected to be hauled out. An attempt is made to survey all known haulout sites, and small corrections are applied to account for any sites that are missed. However, an unknown proportion of non-pups will be foraging at sea (or hauled out at unknown sites) and not included in counts. Based on the number of pups observed during surveys compared to the number expected based on pup production, its estimated that anywhere from two-thirds to nearly all non-pups are counted.

Counts have been made without regard to environmental factors that may affect the proportion of animals hauled out or visible during surveys, such as sea state, tide height, wind speed, and precipitation (although the small aircraft used in surveys can only be safely operated under certain conditions). Other researchers have attempted to adjust Steller sea lion counts for these co-variates, but samples sizes were small and the adjustments had no discernible effect on population trend estimates.

Population trends prior to the first systematic aerial surveys in the early 1970s were reconstructed from historic records of sea lions sightings and kills. Most of these records are for rookeries, and thus insufficient for examining trends in total abundance. However, surveys conducted between 1971-2006, during which period abundance doubled, indicated that a relatively constant proportion (mean 61%; range 51-67%) of the population occurred on rookeries. This suggests that numbers on rookeries provide a good index of total abundance.

Considerable judgment had to be used in interpreting the historic sighting and kill records. In some cases, counts may have been influenced by disturbances associated with control programs and harvests, which could have displaced animals from the site, or disturbances in

adjacent areas that may have driven animals to the site. Some of the counts seem to have been made precisely, while we suspect others were ballpark estimates. Some of the counts were made at sub-optimal times, although in these cases it was sometimes possible to apply crude adjustments based what we know about the chronology of pupping and the arrival schedule of animals on rookeries. The subjectivity involved in the interpretation precludes any formal statistical analysis of historic population trends.

CONCLUSIONS AND ADVICE

Abundance of Steller sea lions in B.C. has tripled and pup production quadrupled since the species was protected in 1970. Populations have also been increasing at similar rates in neighbouring waters in SE Alaska. Combined abundance in this region appears to have been attained and is now about double the estimates of peak historic levels thought to have been present in the early 1900s before any large-scale kills. Given the recent recovery of populations, one might expect natural regulatory mechanisms to begin to play a greater role in local waters.

OTHER CONSIDERATIONS

The recovery of Steller sea lion populations has renewed concerns over their impact on other fishery resources. Our understanding of the feeding habits of Steller sea lions and their role in the ecosystem are still poorly known. Although the earlier predator control programs have not been assessed in detail, one study noted there did not appear to be any noticeable increase in salmon catches following the reduction of sea lions on the Scott Islands. Despite the eradication of sea lion rookeries on the Sea Otter Group in an effort to protect the Rivers Inlet sockeye fishery, sockeye salmon stocks in that area remain critically depressed. Additional research will be required on the diet, foraging patterns, and energy requirements of Steller sea lions to assess fishery interactions.

Although populations have grown in recent years, Steller sea lions still face a number of potential threats. During the breeding season, animals gather in large concentrations on rookeries (70% of pup production occurs on the Scott Islands), at which time animals are vulnerable to disturbances. These concentrations are also vulnerable to environmental accidents, such as chemical or oil spills. Being long-lived and at the top of the food chain, sea lions tend to accumulate contaminants in their tissues, such as heavy metals and organochlorines, that can adversely affect their health.

With the recent shift toward ecosystem-based management, there may be potential for using species like the Steller sea lion as a general indicator of the status of food webs in the North Pacific. In western Alaska where populations have declined precipitously, the rates of decline in different areas were inversely related to the diversity and quality of diet. Captive studies have also identified negative health risks for sea lions feeding on low-fat fish such as pollock. The sharp declines that occurred during the 1980s appeared to coincide with a period of reduced body growth, reduced juvenile survival, and increased incidence of reproductive failure, which are suggestive of nutritional stress.

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